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Bulletin No. 135 - A Study in Annual Egg Production: Based on the Records of a Flock of Seven-Year-Old Hens and Their Progeny

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EXPERIMENT STATION

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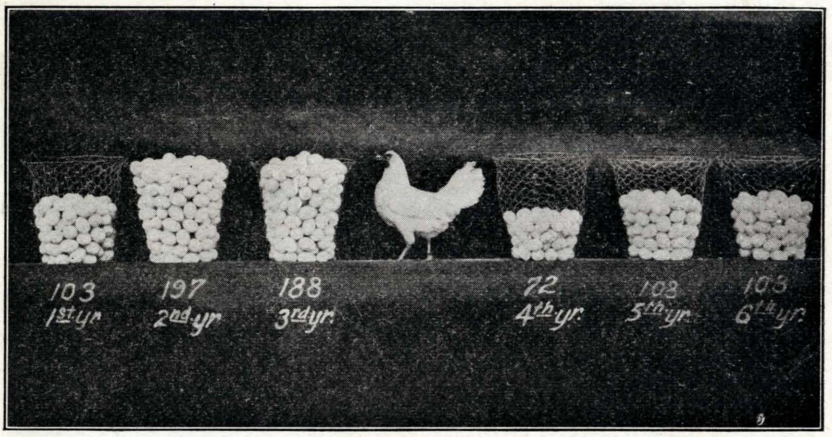

Eggs laid by one hen in six years.

A Study in Annual Egg Production

Based on the Records of a Flock of Seven-Year-Old Hens and Their Progeny

By

E. D. BALL, GEO. TURPIN, and BYRON ALDER

Logan, Utah, July, 1914

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ERRATA. Page 13.

The last line in the fourth paragraph should read:
"second year record was above 125."

The last line in the fifth paragraph should read:
"second year records way below 125."

A STUDY IN ANNUAL EGG PRODUCTION

Based on the Records of a Flock of Seven-Year-Old Hens and Their Progeny

By E. D. BALL, GEO. TURPIN and BYRON ALDER

A. GENERAL CONSIDERATION.

Experimental work in breeding for egg production was started with this flock of Single Comb White Leghorns in 1907. The flock of 1907 was hatched from eggs from a small flock that had been introduced into the plant two or three years before.

The ordinary method of selecting the highest layers of the pullet year and keeping them to produce eggs for next year's hatching was following at first. By this method it was not possible to tell the particular individual from which a pullet came but only that she was from a "high producer" of the previous year as determined by the method used. This did not prove to be satisfactory and so in 1910 the pedigree system, as explained later, was employed. Since that time it has been possible to trace the ancestry and relationship of each individual in the flock and to determine the value and vigor of particular strains.

After two years' records of these flocks had been completed and studied it was found that nearly three-fourths of the first flock had made better records the second year than they did the first and that there was a great variation in the two years' records of individual hens. This raised the question of whether the first year's record was a proper basis of selection—and it was decided to keep a number of hens long enough to test this point.

In the meantime a second line of selection was started by breeding from the poorest layers, and a third by breeding from the medium layers. By breeding from the poorest layers as well as from the best ones, the difference in the results should show the value of the selection used. As, however, it did not appear to be certain that the first year's record was a correct measure of the producing power of a hen, the selection of the medium producers insured that all types of production would be represented in the progeny. If later studies showed that a particular type was the best there would be a number of progeny to select from to continue the work.

Study of an Unselected Flock.

The first result of breeding from high, medium and low producers in each flock, however, was to give a series of flocks of hens that taken as a whole were practically the same as if no selection had been practiced.

As each year's result was added to the records of the original flock it became more and more evident that the first year's record was only a minor fraction of the total production possible to obtain from a hen. They also showed that the total possible production, length of life, range of variation from year to year and ratio of production to age were all factors of which we knew very little.

As all of these factors should be considered in interpreting any results obtained from selection—in fact, all of them should be understood and used in correctly planning an experiment in breeding—it was considered advisable to maintain each flock of hens as near intact as the available facilities allowed, until more light was obtained on a number of these points. In order to keep these old hens it has been necessary to cut down the number of progeny retained each year to between one and two hundred, thus for the present somewhat limiting the number available for selection.

Methods Used.

The fowls were kept in flocks of ten in sections of a long house and were allowed only limited range in a shaded run 10x75 feet with clean cultivation, or a flock of twenty in a 6x8 colony house with practically free range conditions and an abundance of shade and green food during the summer. One rooster was

kept with each flock during the entire year except during 1913, when the males were kept in the pens only during the breeding season which lasted from February 1 to June 1.

All chicks were hatched in incubators and brooded artificially, principally in fireless brooders.

Forced feeding has not been practiced to any extent during the brooding period, nor after the pullets have begun to lay. The aim has been, however, to hatch the chicks early enough and to feed in such a way as to have a majority of the pullets laying before the winter weather set in or about the middle of November. The laying hens of all ages have been fed and handled in the same way. In many cases hens of four or five different ages have been kept in the same pen.

Records Kept.

All eggs selected for breeding purposes were marked with the date and hen number at the time they were taken from the trap nest. Each hen's eggs were kept in a separate compartment in a specially prepared egg case. As soon as six to ten eggs were obtained from a hen the eggs were put into the incubators and a careful record kept of them, so that at the end of the season the records showed the number of eggs set from each hen, the number tested out as infertile, the number that died before the fourteenth day, the number that remained unhatched at the end of the period, the number of cripples or weak chicks hatched and the number of good, vigorous chicks taken from the incubator. About the eighteenth day each hen's eggs were put in a separate wire hatching tray. When the chicks were taken from these trays they were banded with a small chick legband and the number and toe mark of each one was recorded. The date hatched and the band number of the sire and dam was also recorded. The chick bands were spread as the chicks grew until in the fall the legs became large enough to hold the mature or sealed legband. This number was then recorded in a space next to the chick band number and the hen was known from then on by the number of the sealed band. The record of the hatching of each hen's eggs, the number of chicks that survived and the time it took the chicks to mature, as well as the length of life and number of eggs produced, were all considered as factors in determining the vitality of a given strain.

Each pullet has a card on which is recorded its number and the number of the sire and dam, date of birth, date first egg laid, average weight and the weight of the eggs. The original egg sheets are preserved and only the number of eggs laid each month is recorded on the card. The total from November 1 to October 30 of each laying year throughout life is recorded and finally the total number of eggs and the date and cause of death are entered.

Factors Influencing Egg Production.

While studying the egg records of the different flocks it is well to bear in mind that the total egg production of a flock may be affected by a large number of different factors, many of which it is impossible to control. A sudden cold snap early in the fall will often check the egg yield for some time. In the same way a sudden hot wave in the summer may materially reduce the production of that month. Some of those checked in either way may fail to start for a long time. It is impossible to estimate just how much the ordinary variations in climate affect production. Vermin and disease of course reduce production and even the most watchful care of fowls will not prevent slight inroads occasionally.

The time of hatching, method of brooding, character of food, care and housing all affect the time of maturity of the pullet. The first year's record is often considerably higher for those fowls that get just the right "start off," commencing to lay in November or at the latest early in December and continuing throughout the entire year. Those commencing a month or two earlier often moult late in the fall and do not start laying again until early spring, while still others that do not get started before cold weather comes on, wait until early spring before their first eggs are recorded, and in both cases the year's record is considerably lower than in the case where the right start was obtained.

It has not always been possible to so time hatches and regulate feeding in connection with the uncontrollable factors as to insure maturity at the most favorable time.

It will require a long series of records on different flocks under diverse climatic conditions to determine just what is the normal variation in records due to these causes. A study of the records presented shows, however, that a number of these

variable factors are eliminated from the record of the second and third years, and a comparison of the variability of these years as compared with the first year's records gives some indication of the relative influence of some of these factors.

Renewing the Flock.

One of the biggest drawbacks to success in the poultry industry is the problem of renewing the flock. With most strains of fowls the average life of usefulness is considered to be about two years. Under these conditions 50 per cent of the fowls must be replaced every year. A flock of 2000 hens would thus require 1000 good pullets added each year. This would mean an average of 4000 chicks, one-half of which would be lost in brooding or culled out, and at least one-half of those left would be cockerels which are too often raised at a loss. The fact that most egg producers would be glad to buy pullets at the price they receive for the cockerels is a confession that it costs more to produce them to the broiler age than they will bring.

Leghorn chicks can usually be bought in large numbers at ten cents each; with 50 per cent loss or culled out the original cost per chick would be twenty cents. The feed cost would run from thirty cents to forty cents, making the total cost of producing a pullet, outside of equipment and labor, fifty to sixty cents.

The equipment required for brooding chicks in such large numbers is an expensive item, and can only be used for a short time each season. The labor problem is also acute at this time. While the sale of the old stock may possibly balance the cost of these two items still the annoyance and uncertainty of the whole process is one of the most discouraging factors in poultry production today.

The development of a strain of fowls that would be profitable through a longer period of time and thus lower the renewal requirement to one-half or one-third of its present amount would materially reduce the cost of production as well as the worry and hazard of the poultry industry.

Vigor of the Flock.

There have been no serious epidemics of disease nor anything except sporadic outbreaks of vermin during the seven years of the experiment. No serious accidents have occured to in-

terfere with the work. The general vigor of the flocks can best be judged by their longevity and the heavy egg production extending through successive years. The only thing then that needs explanation before studying the records is the remarkable occurrences of the year 1911.

The Year 1911.

Far more of the old hens died during this year than during any other year of the record, and those that survived made the lowest averages yet made by their respective flocks. The 1910 flock making its first record in 1911 made the lowest average yet recorded, not only the lowest first year record but actually lower than any average made before or since by the older flocks except one made that same year.

Not only were the egg records low, but of the eggs that were obtained a smaller number than usual hatched and the chicks seemed to lack vigor and many died, so that this year's flock started out the smallest of the seven.

Taken all in all, the year was a very discouraging one throughout the entire plant, but on investigation the same condition was found to prevail in many parts of the state. Other poultry plants were having the same or even worse difficulties and there seemed to be some general and widely distributed factor responsible for the condition. Just what this was is hard to determine.

B. A STUDY OF THE FLOCK RECORDS.

In studying the flock records it is well to keep in mind that these flocks can scarcely be said to have been "selected" at all for production. It is true that the first flocks were supposed to be the progeny of "high producers," but the first year flock records were so low that in some cases there were very few that produced more that 160 eggs. This number of eggs is supposed to be the lowest limit of a "high producer," and, as will be shown later, there was little or no value in selecting even the few "high producers" that occurred in these flocks with low first year records.

Later selections were made from high, medium and low producers, so that the flock as a whole would scarcely be affected by the selection even if it was producing definite results.

In most cases in other experiments, flocks that have been kept more than one year have been severely selected at the end of the first year's production and only those individuals with first year records of 160 or above retained to make the later records. Nothing of this kind has been attempted in these flocks. In some cases all have been kept, in a few cases some had to be discarded to make room for the later flocks. These were usually rejected on account of lack of vigor, practically regardless of egg production. In a few cases production was used as a basis for rejection, but even in these cases it was only those producing less than 60 that were eliminated.

In one case a few with records above 60 were rejected, but in no case were all below this limit discarded.

With respect to vigor the selection has been much more severe, all apparently weak individuals have been taken out before putting the pullets into pens. In the later years, strains showing low fertility, low rate of hatching, low chick survival or short life have not been used in the breeding work, although the individuals have been continued in the flocks. This has been done regardless of egg production and in several cases has taken out some of the highest producers.

What is Meant by a "Yearly Record."

In giving the "yearly record" of a dairy cow the time from the beginning of one lactation period to a year from that date is usually meant. This is no doubt the best method possible in the particular case, as under modern methods of handling, cows freshen at all seasons of the year and there is no natural time at which a whole herd could be said to begin a yearly record. In a few cases records of fowls have been published in this way, i. e., from the date of laying the first egg until a year from that date. Under our climatic conditions, however, there is a fairly definite normal moulting period in September and October for all the older fowls during which only a few eggs are produced. This makes of November 1st a particularly desirable and natural date to begin a year's poultry record.

As has been suggested above, it is difficult to get the pullets matured at just the right time to enter on their year's work to the best advantage, but this difficulty would be found to be even greater if any other date were selected.

In all of the following tables the year as given begins the November previous, e. g., the flock of 1907 were hatched in April and May, 1907, and made their "1908" record between November 1, 1907, and October 30, 1908.

Number of Hens Completing Records.

In Table No. 1 is shown the number of hens that completed full year records each year by ages, also the number of years' records each flock has made and what proportion of the flock survived or was kept to make the record.

TABLE NO. 1.—NUMBER OF HENS COMPLETING FULL YEAR RECORDS BY FLOCKS.

Flock Hatched In	Number of Hens Completing Records for the Year: '08	'09	'10	'11	'12	'13	Number of Hens Completing Records by Years of Laying 1st	2nd	3rd	4th	5th	6th
1907....	121	91	58	31	24	14	121	91	58	31	24	14
1908....	...	135	98	49	34	23	135	98	49	34	23	..
1909....	...	...	96	73	48	31	96	73	48	31	..	..
1910....	...	...	...	121	100	37	121	100	37	..	..	..
1911....	...	...	...	...	85	53	85	53	..	..	..	..
1912....	...	...	...	...	...	160	160	..	..	..	..	..

This table shows a total of nearly 1500 records, of which over 700 are first year records, over 400 second year and nearly 200 third year ones. Only three flocks have gone beyond the third year, but they have given nearly 100 fourth year records, while two flocks gave half that many for the fifth year and the oldest flock furnished 14 six year records. Besides these records a large proportion of the hens that have died laid from 60 to 100 eggs during the winter and spring of that year and then died during the hot weather or during moulting time. These partial year records have not been counted but have been credited to the hen in the total production given in later tables.

What is the Average Life of a Hen?

The work has not progressed far enough yet to give a very definite answer as to the productive life of a hen—so many factors of variation in climate, freedom from disease, vigor, food, etc., enter that it will take a long series of years before any definite averages can be taken. Table No. 1 shows, however, that

the average productive life of the hens in this experiment has been a great deal longer than was popularly supposed.

Chickens die at all ages, from the time they leave the incubator on. The brooding loss is usually the greater part of that of the first year. The greatest loss in older hens almost always comes during the heat of summer or during the moulting period. As the figures in the table are only of hens that completed the year's record, they need to be advanced practically one year to show the number of hens living and laying up to midsummer.

In making up pens to even groups of tens a number of hens were omitted; others were crowded out to make room for the growing chicks in a limited plant; some few lost their leg bands, while out of the pens and could not be returned. A few were stolen. To offset these losses it would be necessary to increase most of the figures by one-fourth. With these corrections in mind it appears that about one-half the hens if kept, would have lived through till moulting time of the fourth year, one-third to the fifth and one-sixth to the sixth year. The year 1911 was, however, an exceedingly hard year on poultry, as has been explained above. One-half of the two oldest flocks dropped out that year. Later flocks may show a lower death rate at the same age and consequent longer productive life.

TABLE NO. 2.—AVERAGE YEARLY PRODUCTION OF ALL HENS COMPLETING ONE OR MORE YEARS' RECORDS, BY FLOCKS.

Flock Hatched In	Average of Flock for the Year: '08	'09	'10	'11	'12	'13	Average of Flock for Year of Laying: 1st	2nd	3rd	4th	5th	6th	Three Year Avge.
1907...	107	135	117	78	87	93	107	135	117	78	87	93	120
1908...	...	136	105	82	90	89	136	105	82	90	89	...	108
1909...	...	...	155	101	113	103	155	101	113	103	...	...	119
1910...	...	...	...	86	137	136	86	137	136	...	...	...	120
1911...	...	...	...	...	114	133	114	133	...	...	...	...	...
1912...	...	...	...	...	...	153	153	...	...	...	...	...	...

Yearly Averages of All Flocks.

Table No. 2 shows the average number of eggs laid by each flock each year to date. In this table every hen that completed records as shown in Table No. 1 is considered. The individual hen records for each year are shown by flocks in later tables. Tables Nos. 14, 15, 16 and 17 contain each year's production of

all hens that have completed three or more years' records. Table No. 18 contains the records of all those completing only two years' records up to the flock of 1911, while Table No. 19 gives those of the same flocks, with only one year's record. The individual records of later flocks will be published after they have completed three years or more of records.

Range of Variation in First Year Production of Flocks.

From Table No. 2 it is seen that the lowest first year production of any flock is 86 and that the highest first year production was 155. The record of 86 was made in 1911 and is doubtless abnormally low. Discarding this, the records indicate a variation between about 100 on the one hand and 160 on the other as the normal ranges of flock variation in first year production for this strain of fowls. Any fluctuation between these two limits, even if persisted in for two or three successive years, would not necessarily mean that any heritable variation had been produced, nor that the next year might not see the pendulum swing to the other extreme.

Range of Variation in Second Year Production of Flocks.

The range of variation shown is from 101 to 137, but the 101 record was made in 1911 and is no doubt low. Discarding that, the range appears to be between about 105 and 140. The lower limit of 105 seems to be sufficiently low for normal variation when it is noticed that three out of the four remaining records (omitting 1911) are above 130. At any rate it is noticed that the **range** in variation for the second year record is but little over one-half as much as in the first year's production.

Range of Variation in Third Year Production of Flocks.

Omitting the 1911 record of 82, as being abnormally low, we have only three records left, which is too few to be of much value for direct comparison. Comparing the averages of the previous years with the averages of those that follow, however, indicates that the 136 is an extremely high record—probably partly the effect of the extremely low first year record of the flock and partly the result of some selection in making up pens, as we note that only one-third of the original flock is left to make the third year record. With these comparisons in mind the probabilities seem to be that the 113 and 117 records are

about normal and that the range of variation would be between 100 and 130.

Range of Variation in Flock Averages after the Third Year.

Omitting the 1911 record of 78, as before, we have left five records, four of which range close to 90 and indicate that after the third year there is a fairly constant average of about that amount with a range of variation of only 10 or 15 in all. There does not, in the figures available, seem to be any progressive decline after the third year, but the number of flock records is small and the number of hens in a flock these later years is also much smaller, consequently the averages of the last year or two are of less value than those of the larger numbers in the first three years.

The range in flock variation, therefore, appears from the records available, to be for the first year about 60, for the second year 35 and for the third year 30 and for the fourth year and after, not more than 10 or 15.

Comparison of the First, Second and Third Years' Production and of the Average of the First Three Years.

The most interesting thing about Table No. 2 is the comparison between low and high first year production in the effect that it has on the second year's production and on the average of the three years.

There have been three years in which the first year production fell below 125 and three years in which it was above that amount—the average of the six years being exactly this figure, but no single record has been near this number—the low ones being far below and the high ones considerably above. In each of the three flocks with a low first year's record the second year records away below 125.

One high flock has not completed its second year record. The other two flocks with high first year records have given second year record was above 125.

The highest first year record was followed by the lowest second year one and the lowest first year record was followed by the highest second year one. In fact, arranging the first year records in an ascending order, as in Table No. 3, gives the second year record of the same flocks in a reverse order without exception.

Table No. 3—Flock Averages Arranged in Order of First Year Production.

First Year Records	86	107	114	136	155
Second Year Records	137	135	133	105	101
Third Year Records	136	117	---	82	113
Average of Three Years	120	120	---	108	119

The third year's records so far made run in the same order as the second with one exception and that of the year 1911.

From Table No. 3 it will be seen that the flocks with the lowest first year record made not only the highest second year record but also the highest third year record and a higher average for the three years than the highest first year flock did.

The Uniformity of the Three Year Average.

The most striking thing about Table No. 3 and one of the most startling things brought out in the entire study of the flock records is the remarkable agreement of the three year averages. The medium flock on first year production (and also on second) has not completed its third year record. Assuming that it would have the "average" third year production (its two years' production is almost exactly "average") which would be 112 and we would get a three year average for the flock of 120.

This would give three flock averages of 120, one of 119 and one of 108—or four out of the five flocks averaging for the first three years' production between 119 and 120 eggs per year regardless of whether their first year record was extremely high, extremely low or just average. The only exception to this remarkable record being the flock that made its low third year record in 1911 and had no chance to make up for it later.

The only conclusion that can be drawn from this remarkable agreement is that an unselected flock of hens of a given strain has a certain potential laying capacity in its first three years and that it makes very little difference how many eggs are laid in either of the first two years as the balance will be produced in the other two. If the first year's record is remarkably high it will be followed by a very low one. If, on the other hand, the first year's record is very low the second year's record may be as high as 50 eggs per hen above it.

The record beyond the third year of laying also indicates that there is a very definite mean laying capacity for flocks of old hens which is not subject to much fluctuation from year to year. This, taken with the remarkably uniform averages of the first three years' records, indicates that there is a pretty definite potential laying capacity for this strain of fowls.

The Total Possible Production of a Hen.

The total possible production of a hen is a matter, like the possible length of life, still to be determined. The writers have not been able to find a record of a flock of hens that have been kept until their death from old age. A few flocks have been kept for three years, but in most cases only a selected few of the best of the first year's layers have been kept that long.

TABLE NO. 4—NUMBER OF HENS PRODUCING 500 EGGS OR OVER UP TO DECEMBER 1, 1913, BY FLOCKS.

Flock Hatched In	Total Number of Hens Producing Over					Number of Hens Living Dec. 1st by Production				Total Hens Living Dec. 1st
	500	600	700			Under 500	Over 500	Over 600	Over 700	
1907	26	17	6	..	..	1	13	12	6	14
1908	21	12	1	..	..	6	17	11	1	23
1909	14	4	0	..	..	20	11	4	..	31
1910	1	0	0	..	..	36	1	..	..	37
Total	62	33	7	..	..	63	42	27	7	105

Table No. 4 shows the total number of hens in each of the first four flocks that have laid over 500 eggs and how many they have laid by hundreds. It also shows the number of hens in each flock living at the beginning of December, 1913, and what their record to date has been. From this table it will be seen that 62 hens of these flocks have laid over 500 eggs each, that 33 of these have laid over 600, and seven of them over 700 eggs each. The highest record is 771 eggs to date. Of the 7 with records above 700 all are living, while of the 26 that laid between 600 and 700 eggs, twenty are now living. Some of these twenty-seven hens with records from 600 to 771 to date will no doubt make some pretty high additions to these already high records in the next two or three years.

Looking at the flock records we see that of the first flock, all but one of the living hens has laid over 500 eggs, all but two

over 600, and nearly half of them over 700 eggs. Half of the next flock have laid 600 eggs or over, while of the youngest flock with only three years' record only one has reached the 500 mark.

TABLE NO. 5.—AVERAGE YEARLY PRODUCTION OF HENS COMPLETING THREE OR MORE YEARS' RECORDS BY FLOCKS.

Flock Hatched In	Average of Flock for the Year: '08	'09	'10	'11	'12	'13	Average of Flock for Year of Laying: 1st	2nd	3rd	4th	5th	6th	Three Year Avge.
1907.....	117	146	117	78	87	93	117	146	117	78	87	93	127
1908.....	...	153	117	82	90	89	153	117	82	90	89	...	117
1909.....	...	...	156	111	113	103	156	111	113	103	...	...	127
1910.....	...	...	...	94	151	136	94	151	136	...	...	...	127

Yearly Averages of Hens Laying Three Years or Longer.

Table No. 5 includes only flocks that have made three year records and only considers hens in these flocks that completed three or more years of laying. This table is made up directly from the averages of the individual hen records shown in Tables Nos. 14 to 17. The elimination of all hens that completed only one or two years' records changes all the figures in the first two years of each flock—the other figures being the same as shown in Table No. 2.

This table gives a much better means of comparison between first, second and third year records because in this case the records have been made by the same hens.

The first two years' averages are higher in every case than they were in the total flock, due mainly to two causes. Those hens lacking in vigor and consequently making poor records either in the first or second year or both have mostly died and dropped out before the end of the third year. Secondly, in making up pens, if any were omitted, and in most cases some had to be, those apparently lacking vigor or making poor records were the ones left out. Studying these records, we see that the range in first year variation is still about 60 eggs, that the second year variation has been reduced to 40 or less as in the previous table. In the same way we see that the highest first year record is followed by the lowest second and vice versa.

Arranging these flock averages according to first year's production as in Table No. 3 and we get Table No. 6 with the second year's records just reversed on the first as before and even more striking uniformity in the three year average.

Table No. 6—Flocks of Hens With Three Years' Records Arranged in Order of First Year Production.

First Year Record	94	117	153	156
Second Year Record	151	146	117	111
Third Year Record	136	117	82	113
Three Year Average	127	127	117	127

Leaving out the one year with the low 1911 record coming at the end, thus allowing no chance to make up within the period, and the remaining records are exactly alike, showing a three year average of 127 eggs per year. The other record would come within one egg of equalling the others if the lowest normal record was substituted for the 1911 one, and that one egg would be in excess.

Comparing the average of first, second and third year production, we get slightly different results according to the data used.

Table No. 7—Comparison of First, Second and Third Year Production.

	1st	2nd	3rd
From Table No. 5 all hens three years old or older	130	131	112
From Table No. 2 from flock with three year record	121	120	112
From Table No. 2 from flocks with two year record	120	122	112
From Table No. 2 from all flocks	125	122	112
Average of all	124	124	112

The differences are so slight, however, that the average of all the methods of comparison is probably as correct an expression of the ratio in an unselected flock as could be found. This average shows an average production for the first year of 124, for the second of 124 and for the third of 112, or, that there is no difference between first and second year production and

that the third year production only falls off about one dozen eggs.

C. A STUDY OF THE INDIVIDUAL RECORDS.

After studying the flock averages and noting their variation from year to year, the question naturally arises whether these variations are reflected throughout the individuals of the flock

TABLE NO. 8—RELATIVE DISTRIBUTION OF HENS IN FLOCKS EACH YEAR ACCORDING TO PRODUCTION.

Year of Laying	Number of Hens Producing Between												No. of Hens	Flock Avg.		Standard Deviation
	220 239	200 219	180 199	160 179	140 159	120 139	100 119	80 99	60 79	40 59	20 39	0 and 19				
1907.																
1st year.	..	..	3	8	11	24	19	29	16	8	3	...	121	107	...	36.3±1.6
2nd year..	..	2	3	13	28	17	14	7	5	1	1	...	91	135	...	34.1±1.7
3rd year..	..	..	1	2	9	22	10	9	1	2	1	1	58	117	...	32.6±2.0
4th year..	..	..	..	..	..	..	9	8	6	6	2	...	31	78	...	25.3±2.2
5th year..	..	..	..	..	2	..	9	4	3	3	3	...	24	87	...	33.8±3.3
6th year..	..	..	..	..	1	1	4	6	..	1	..	1	14	93	...	32.2±4.1
1908.																
1st year..	..	6	7	16	35	29	24	11	4	3	..	..	135	136	..	34.3±1.4
2nd year..	..	1	1	3	13	19	25	14	6	9	5	2	98	105	...	39.6±1.9
3rd year..	..	..	..	..	1	7	7	12	9	6	5	2	49	82	...	34.5±2.4
4th year..	..	..	..	1	..	7	10	5	..	4	5	2	34	90	...	41.5±3.4
5th year..	..	..	..	..	..	4	7	6	2	1	1	2	23	89	...	34.9±3.5
1909.																
1st year..	3	7	18	14	18	22	5	7	2	..	..	..	96	155	...	37.2±1.9
2nd year..	..	1	3	3	3	14	10	18	10	4	6	1	73	101	...	43.4±2.4
3rd year..	..	..	..	1	7	17	9	6	4	2	2	...	48	113	...	32.3±2.2
4th year..	..	..	..	1	5	4	6	7	5	3	..	...	31	103	...	32.9±2.9
1910																
1st year..	..	..	..	1	3	12	21	34	26	19	4	1	121	86	...	29.4±1.3
2nd year..	1	2	11	16	21	18	14	7	6	3	1	...	100	137	...	39.8±1.9
3rd year..	..	1	1	6	11	8	5	4	1	..	..	...	37	136	...	30.2±2.4
1911.																
1st year..	..	..	4	4	13	15	21	11	6	9	2	...	85	114	...	38.4±1.9
2nd year..	..	1	4	9	8	11	11	6	2	1	..	...	53	133	...	35.1±2.3
1912.																
1st year..	2	8	25	35	39	24	15	5	6	1	..	...	160	153	...	34.8±1.3
Tot. Rec.	6	29	81	133	228	275	255	216	120	86	41	12	1482	...	...	

or whether in a year of highest production, for example, the result is obtained by a few very high producers while the rest of the flock remains the same as usual. Table No. 8 shows the distribution of the individual records by twenties throughout each year of laying for all flocks. Table No. 9 shows the difference between the highest record and the lowest one each year or the range of variation between the individuals of a flock.

TABLE NO. 9—RANGE OF VARIATION IN YEARLY PRODUCTION OF INDIVIDUALS BY FLOCKS.

Flock Hatched In	Difference Between the Number of Eggs Laid by the Highest and Lowest Producers Each Year					
	1st Yr.	2nd Yr.	3rd Yr.	4th Yr.	5th Yr.	6th Yr.
1907	169	187	171	91	117	131
1908	177	196	128	153	135	...
1909	180	193	108	118	...	...
1910	145	186	133	...	...	...
1911	156	150	...	...	...	...
1912	192	...	...	...	...	...
Average	170	182	135	121	126	131

These tables will be discussed by years of production, but in general it will be noticed that the distribution of the individuals in each flock shows conclusively that whatever it is that causes variation in flock averages affect all the individuals of the flock in about the same proportion. If the flock average is high in a given year then the individual records will be about the same amount higher than in a low year, and with about the same frequency of distribution throughout the series. From Table No. 9 it is seen that the range in variation fluctuates from year to year, but, except in the first year, does not follow closely the variation in flock averages.

Range of Individual Variation in First Year Production.

From Table No. 8 it will be seen that out of the twelve spaces shown, the first year records are distributed in every case, except in the last, through nine of them and in this last case only one individual extends to the tenth space. The extreme variation possible in nine spaces would be between 160 and 180, while we see from Table No. 9 that the average range

of first year variation is exactly between these figures or 170.

Studying further we see that in the two highest laying years the records are distributed in the nine highest spaces; in the lowest year they are in the nine lowest spaces; and in the intermediate years they are distributed in the nine intermediate spaces,—omitting sometimes one and sometimes two at either end. The distribution within the nine spaces is in every case what would be expected from the law of chance and indicates very strongly that whatever factors influence the yearly average of the flock, operate uniformly on the individuals making up the flock.

Range of Individual Variation in Second Year Production.

There is a decidedly wider range of variation in second year production than in the first. Of the five flocks with second year records only one is confined to nine spaces, one to ten and the other three are distributed through eleven spaces—checking this with the results in Table No. 9 and we see that the actual range is higher in every case and the average range 182, is twelve higher than in the first year.

Just why the individuals should vary more the second year than the first while the flock averages vary only a little over one-half as much is not clear. This wide variation is, however, more apparent than real, because by eliminating not more than two extreme individuals from each flock the range of variation would fall below that of the first year. There does not seem to be any correlation between the flock averages and the range of variation.

Range of Individual Variation in Production After Second Year.

The range in individual variation falls suddenly after the second year. This will be noted in both Tables Nos. 8 and 9. Except in one instance the variation after the second year is less than in the first year and in the later years it falls gradually from that found in the third year. The range of variation is practically the same in the highest third year record (1910 flock) as in the lowest one (1908 flock). The later years' records are so few in number as yet that they can only be used for broad comparisons.

TABLE NO. 10—AVERAGE NUMBER OF EGGS LAID BY EACH TEN OF EACH FLOCK, ARRANGED ACCORDING TO FIRST YEAR PRODUCTION.

Flocks Arranged in Tens According to 1st Year Records	Average Production of the Tens in Given Years						Average Production			3-Year Total
	'08	'09	'10	'11	'12	'13	2nd Yr.	3rd Yr.	4th Yr.	
1907										
1st 10	168	149	113	78	40	98	159	143	125	430
2d 10	143	156	131	79	86	89	150	143	126	429
3d 10	121	151	121	88	82	100	136	131	119	393
4th 10	104	144	124	90	108	96	131	124	130	372
5th 10	90	140	106	69	83	68	120	112	100	336
6th 10	71	135	110	71	99	116	103	105	104	315
Flock Average	117	146	117	78	87	93	133	126	117	379
1908.										
1st 10	...	202	137	109	117	85	170	149	140	448
2d 10	...	171	120	91	111	99	146	127	123	382
3d 9	...	153	137	91	96	109	145	127	123	381
4th 10	...	134	108	65	53	39	121	102	84	306
5th 10	...	104	85	57	66	99	95	82	78	246
Flock Average	...	153	117	82	90	89	135	117	110	353
1909										
.....	...	...	200	140	132	125	170	157	146	472
1st 10	...	...	181	119	125	112	150	142	128	426
2d 10	...	...	160	114	111	91	137	128	124	385
3d 8	...	...	139	114	99	90	127	117	120	352
4th 10	...	...	101	71	96	92	86	89	92	268
Flock Average	...	...	156	111	113	103	134	127	121	380
1910										
1st 10	...	...	...	128	169	141	149	146	...	438
2d 10	...	...	...	96	144	145	121	129	...	387
3d 7	...	...	...	85	138	133	112	119	...	357
4th 10	...	...	...	62	147	124	105	111	...	334
Flock Average	...	...	...	94	151	136	122	127	...	381

Comparison of First, Second and Third Production of Individuals, On First Year Rank.

Table No. 10 gives a summary of all individuals that have made three year records or more as shown in Tables Nos. 14 to 17. These were rearranged and ranked according to first year production by tens within their respective flocks, the odd num-

bers being placed as near the middle as possible so that highest and lowest, even tens, twenties, etc., might be compared. This table gives only the averages of the tens.

Of the four flocks shown two made exceptionally high first year records (153 and 156) and two very low ones (117 and 94) as shown by the flock averages.

Comparing the highest ten of each flock with the lowest on first year production, we see that there is a difference of almost exactly 100 eggs in each case except the low record of the year 1911, where the difference is less than 70 and even this is probably partly due to the small number in the flock as compared with the others.

Taking the second year records of these flocks, we see that in those with high first year's records there is a difference of 52 and 69 in the second year results or a little over one-half as much difference as there was in the first year, while the third year shows still less. On the other hand, the two flocks with low first year records showed in the second year's production very little correlation with the first year. In one flock the highest ten of the first year was only three eggs above the average and the lowest ten only eleven below, while the highest averages were produced by the intermediate flocks. In the other flock the highest second year average was from the highest ten but the second highest came from the lowest ten on first year production. The third year records show the same tendencies, the highest averages in both cases following the intermediate tens.

Making this comparison in another way, we notice that while there is approximately 100 eggs' difference between the highest and lowest tens in the first year in all cases, that for the two highest flocks, the difference between the highest and lowest three year totals is almost exactly 200, while for the two low flocks it is only a little over 100. In other words where a flock makes an extremely high record the first year, those individuals making the highest records will on the average continue to make much higher records than those making low first year records. If, on the other hand, a flock makes a low first year record, then the production for the next two years is likely to be about the same for the high producers and the low and at the end of the three years the difference in their

total production will be practically all the result of the first year's variation. In one case three of the intermediate **tens** produced more in the second and third years than the highest ten did.

In this connection it is well to bear in mind that the flocks making the highest first year records have not produced any more eggs in three years than those with extremely low first year's records.

On the Production of the Ten Highest Individuals.

By selecting from those with at least two years' records in each flock the ten highest in first year production, and taking their second and third year records; then taking the ten highest

Table No. 11—The Total Production of the Ten Highest Hens of Each Flock in Each of the First Two Years.

Flock of	Ten Highest First Year	Their Second Year	Their Third Year	Totals Two Years	Totals Three Years	Ten Highest Second Year	Their First Year	Their Third Year	Totals Two Years	Totals Three Years
1907	169	146	106	315	421	187	125	137	312	449
1908	203	139	117	342	459	166	164	117	330	447
1909	200	140	132	340	472	172	185	144	357	501
1910	138	154	151	292	443	197	105	174	302	476
1911	167	155	---	322	---	184	140	---	324	---
Ave.	175	147	127	322	449	181	144	143	325	468

on second year production and adding their first and third year records a comparison can be made between the value of first year and second year records as a basis of selecting high layers. Table No. 11 gives the averages of tens selected from each flock by each method.

The averages of the two years' totals show only a slight difference in favor of the second year, but when the third year's records* are added the three years' totals and the difference be-

*The 1911 flock has not completed its third year record yet and a few hens from the other flocks did not complete three year records.

tween the final averages of 449 for the first year and 468 for the second year shows that a high second year record is a somewhat better indication of a high laying capacity than a high first year one.

The Year in Which the Highest Record Was Made.

From Tables Nos. 14 to 17 each individual record was studied to see in which year the highest record was made and how many years' records were as high or higher than the first year's. The results are presented in Table No. 12.

Table No 12—Showing the Year in Which the Highest Record of Each Hen Was Made. (Hens With Records for Three Years or More.)

Flock of	Number of Hens Making Highest Record						No. of Records	
	1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	Below 1st Year	Above 1st Year
1907	13	41	4	0	0	0	95	95
1908	38	7	0	1	3	-----	140	14
1909	39	4	3	2	-----	-----	114	12
1910	1	24	12	-----	-----	-----	7	67
Total	91	76	19	(3)	(3)	(0)	356	188

From this table it will be seen that in these four flocks 101 of the highest individual records have been made after the first year and only 91 during this year. Even more striking than this is the fact that three individuals made their highest records the fourth year of laying, three the fifth year and that two flocks have not yet completed their fifth year and their records will no doubt increase these figures. All four flocks have completed their third year record and nineteen hens made their highest records in this year.

Considering those hens with only two years' records and tabulating in the same way for each individual the year in which the highest record was made we get Table No. 13.

Table No. 13—Showing the Year in Which the Highest Record Was Made. (Hens with only two year record.)

Flock of	Number of hens making highest record. First Year	Second Year
1907	15	18
1908	39	10
1909	24	1
1910	8	55
1911	16	30
From Table 12	91	76
Total	193	190

From these tables we see that practically one-half of all hens making two year records have made a higher record in the second year than they did in the first and of those that lived quite a number have made still higher records in even later years.

Turning back to Table No. 12, the last two columns show that over one-third of all the annual records made by hens over three years old have been higher than their first year records. This includes the records of the fourth, fifth and sixth years of the older flocks.

From this study of the individual records it is evident that for this strain of fowls as many or more of the highest individual records may be expected during the second and third or even later years than during the first year and that those individuals making their highest records the second year will on the average produce more eggs in three years than those making the highest record the first year.

It is also true of the strain that individuals making an exceedingly high record one year very rarely hold their place a second or third year, but that their three years' averages are made up of both high and low records, or in some cases, of three intermediate records.

Figures Nos. 1 and 2 show graphically the variation in production of two flocks—one, (1907) with a low first year record and the other (1909) with a high record the first year. In both cases it will be seen that the extremely high records are usu-

ally followed by low ones and low ones by high ones and that only in a few cases has the three year average been made up of three intermediate records.

D. POSSIBILITY OF IMPROVEMENT BY SELECTION.

Whether it is possible to improve a flock by selection of high laying individuals cannot be determined by the records

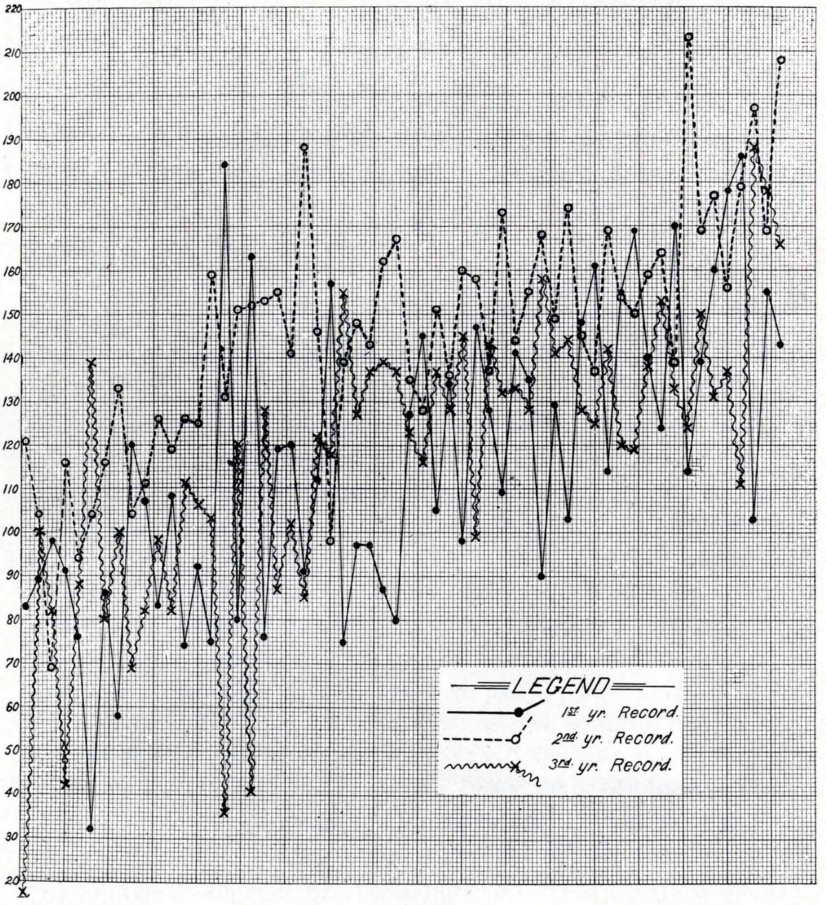

Fig. 1.—Three years' record of the flock of 1907. Note the wide variation in production of the individual hens in the different years.

of this flock thus far considered. In fact, that part of the material has been reserved for a later publication. The material already presented does, however, appear to show quite conclusively that any statements to the effect that there is no value

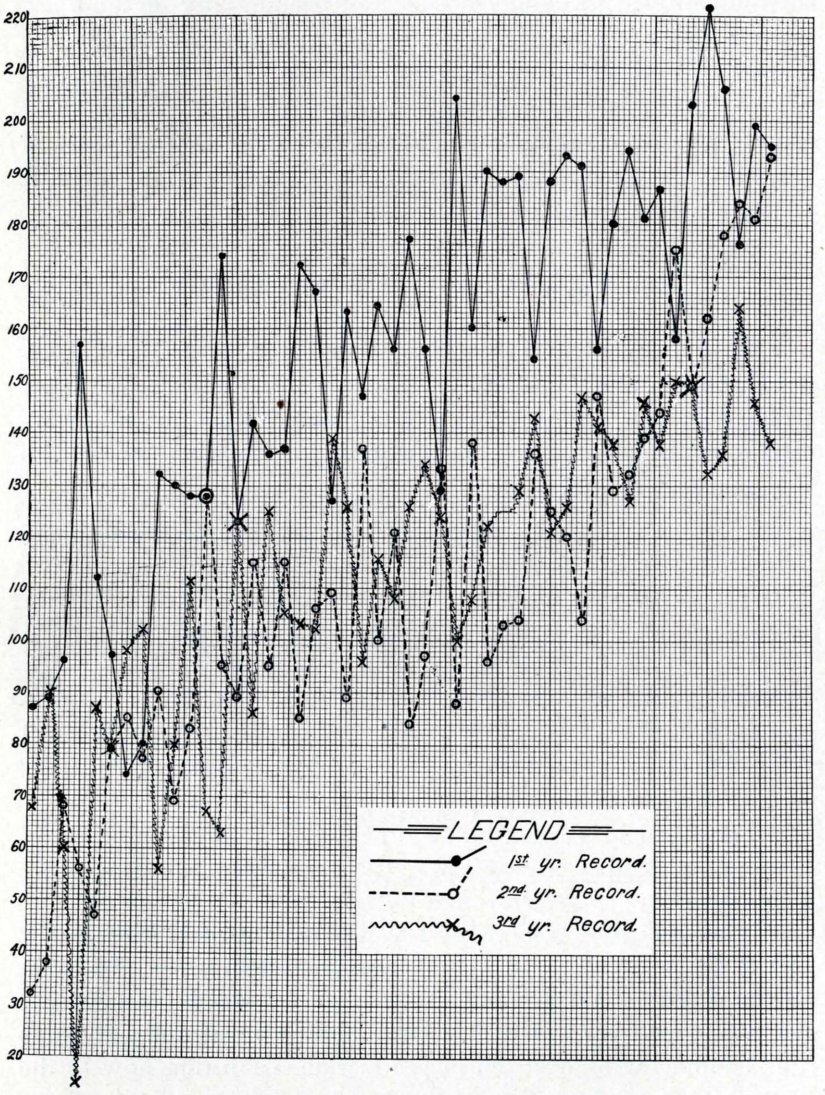

Fig. 2.--Three years' record of the flock of 1909. Note the almost complete reversal of points in the first and second year lines.

in selection must be based upon something more than ordinary variations in first year flock averages to be worthy of any serious consideration. As has been pointed out above, the normal range in variation of first year flock averages appears to be between 100 and 160 eggs, and even variations beyond these limits

have not proved to be any measure of productivity of the flock. Instead the flock with the lowest first year record made the highest second and third year records and as high a total record for three years as has been made by any flock. With these results in mind it seems doubtful whether even several years of low first year records in succession would warrant any definite statement as to the value of selection.

Value of Selecting on First Year Records.

Turning again to Table No. 10 and adding the second and third year production together (or subtracting the first year production from the three year total) and we get the following results, arranged in order of the tens, for the two flocks with low first year records.

		Highest Ten	Second Ten	Third Ten	Fourth Ten	Fifth Ten	Lowest Ten
1907	1st Year	168	143	121	104	90	71
	2nd and 3d Years	262	286	272	268	246	244
1910	1st Year	128	96	85	62		
	2nd and 3d Years	310	291	272	272		

From this we see that three of the intermediate tens in the 1907 flock laid more their second and third years than the highest ten did and that even the lowest ten averaged 122 eggs per year these two years, which is profitable in itself and only nine eggs behind the highest ten in production. Turning now to the 1910 flock we find that there is a gradual falling off in production of the tens, but even the lowest one averaged 136 eggs per year the second and third years. This is higher than the average of the first year records of the different flocks, so there does not seem to have been any place where selecting from these two flocks at the end of the first year would have helped the records of the Poultry Plant to any extent.

Taking the two high flocks in the same way we get the following:

1908	1st Year	202	171	153	134	104
	2nd and 3d Years	246	211	228	172	142
1909	1st Year	200	181	160	139	101
	2nd and 3d Years	272	245	225	213	167

In these two flocks quite different conditions prevail. It will be noticed first that the highest second and third year production of these flocks correspond with the lowest of the two previous ones and that they fall off fairly regularly from this to very low records.

The lower tens of these flocks might well be eliminated after the first year as their production is well below the average of the second and third year records (118) and to keep them would lower the average of the flocks. The higher tens have also demonstrated their value as high producers and might be selected as high laying mothers.

It therefore seems that when a flock makes an extremely high record its first year that selecting on the basis of that record will be of some advantage but that in a flock that makes a low first year record the selection of the highest individuals will not give any marked improvement over the average of the flock.

Some Individual Records.

One of the highest records seen by the writers is that of a German hen that in seven years laid almost one thousand eggs. This record has been republished by Doctor Pearl in Main Station Bulletin No. 205 as follows:

First Year	Second Year	Third Year	Fourth Year	Fifth Year	Sixth Year	Seventh Year	Total
105	163	138	159	160	133	111	969 eggs

One of the best hens yet produced in the Utah experiments is No. 200 whose record for one year less than that of the German hen follows:

1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	Total
103	197	188	72	108	103	771 eggs

The striking thing about both these records is the low first year production—in both cases away below the average of the flocks and so low that on almost any basis of selection these hens would have been discarded. Another striking thing is the fact that not one of the individual year records is particularly high. No. 200 has never been the high hen of any year, but with the exception of the year 1911 she has kept consistently at it.

Of the six hens of the first flock that have laid over 700 eggs in six years not one laid as many as 160 eggs the first year, so that if that had been the lower limit of selection, as it has been in most experiments, all of these hens would have been culled out.

Two other of these high producing hens have records that are worthy of consideration, as follows:

1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year	Total
91	188	85	86	147	144	741 eggs
80	151	120	87	144	131	713 eggs

The low first year production, together with the high production of the fifth and sixth years, gives in these instances an exaggerated illustration of the futility of undertaking to select high producers from first year records of a flock that made a low first year average.

Take, on the other hand, the highest producers of a flock with a high first year average and we see high first year records as follows:

1st Year	2nd Year	3rd Year	4th Year	Total
195	193	138	161	687 eggs
203	149	149	152	653 eggs

Even in this case, however, the lowest first year record made

the highest total. In comparing the total production of these different examples the relative ages must be kept in mind. For example, the last two cases cited are over 100 eggs ahead of the record of the German hen at the same age.

The 200 Egg Hen.

Hens that lay over 200 eggs in a year are fairly common. They have appeared in all six flocks under consideration, but only in three of the six flocks in the first year. In selected flocks under force feeding, such as in egg laying contests, etc., the majority may be expected to reach this record if all conditions are favorable. The highest record in our flocks has been 272 eggs up to the end of the pullet year, or 248 eggs from November 1 to October 30 following. A number of yearly records running up to 270 or above have been made and the Oregon Station last year announced a record of 303.

The question then arises—is it the extremely high producing individual or the high flock average that should be the object of our breeding work. If the answer should be the individual, then the further question—should it be the first year record, a later one or the sum of several years' records that should be considered.

A study of the records so far made does not indicate that extremely high production in the first year is conducive to long life or to consistent high laying. The hen that laid 272 eggs the first year died early in the second year. Another one that laid 242 eggs the first year died before the close of the second.

Six hens in the first flock have laid over 700 eggs—their first year's records are as follows arranged in order of the total production—the highest first:

103	91	155	141	148	80

Three of the six were below the average of the flock; three were considerably above, but not one in the highest ten of the flock. Only two individuals in the 1907 flock laid more than 200 eggs in any year, they are both dead. One of these finished the third year and one the fourth.

On the other hand, in the flock of 1908 six hens laid over 200 eggs the first year; three of these are now dead; of the three still living one has made the highest record of the flock—the one record above 700—while one other has made one of the eleven records above 600.

TABLE NO. 14—PRODUCTION BY YEARS OF ALL HENS IN FLOCK OF 1907 THAT FINISHED THREE OR MORE YEARS' RECORDS.

Hen							Averages			Total Production			
No.	'08	'09	'10	'11	'12	'13	2 Yr.	3 Yr.	4 Yr.	3 Yr.	4 Yr.	5 Yr.	6 Yr.
389..	143	208	166	70	(29)	.....	*176	172	147	517	587	(616)	.....
244..	155	169	178	(3)	.....	.....	162	167	...	502	(505)	.....	.....
200..	103	197	188	72	108	103	150	163	140	488	560	668	771
231..	186	179	111	(61)	.....	.....	183	159	...	476	(537)	.....	.....
261..	178	156	137	91	.....	.....	167	157	141	471	562	.....	.....
218..	160	177	131	(2)	.....	.....	*169	156	...	468	(470)	.....	.....
236..	139	169	150	(13)	.....	.....	154	153	...	458	(471)	.....	.....
374..	114	213	124	(19)	.....	.....	164	150	...	451	(470)	.....	.....
221..	170	139	133	78	(82)	.....	*154	147	130	442	520	(602)	.....
414..	124	164	153	(79)	.....	.....	144	147	...	441	(520)	.....	.....
216..	140	159	138	67	.....	.....	150	146	126	437	504	.....	.....
162..	169	150	119	(20)	.....	.....	159	146	...	438	(458)	.....	.....
204 ..	155	154	120	112	106	91	155	143	135	429	541	647	738
386..	114	169	142	(40)	.....	.....	142	142	...	425	(465)	.....	.....
226L	161	137	125	100	45	(1)	149	141	131	423	523	568	(569)
213L	148	145	128	103	107	86	147	140	131	421	524	631	717
336..	103	174	144	106	(62)	.....	139	140	132	421	527	(589)	.....
387..	129	149	141	68	62	(4)	139	140	122	419	487	549	(553)
256..	90	168	158	102	76	46	129	129	129	416	518	594	640
255..	135	155	128	94	105	.....	145	139	128	418	512	617	.....
279L	141	144	133	105	116	95	143	139	131	418	523	639	734
161..	109	173	132	78	113	.....	141	138	123	414	492	605	.....
224..	128	137	143	.....	.....	.....	*133	136	...	408	.....	.....	.....
158..	147	158	99	39	43	.....	158	135	111	404	443	486	.....
276..	98	160	144	.....	.....	.....	*129	134	...	402	.....	.....	.....
159L	134	136	128	43	30	(12)	135	133	110	398	441	471	(483)
211L	105	151	137	104	104	88	128	131	124	393	497	601	689
242..	145	128	116	81	97	83	137	130	118	389	470	567	650
352..	127	135	123	87	101	100	131	128	118	385	472	573	673
267L	80	167	137	90	92	(6)	123	128	119	384	474	566	(572)
265L	87	162	129	115	117	(25)	125	126	123	378	493	610	(635)
252..	97	143	137	.....	.....	.....	*120	126	...	377	.....	.....	.....
290..	97	148	127	(56)	.....	.....	*123	124	...	372	(428)	.....	.....
274..	75	139	155	47	89	102	107	123	104	369	416	505	607
250..	157	98	118	(61)	.....	.....	126	123	...	369	(430)	.....	.....
373..	112	146	122	.....	.....	.....	* 129	123	...	380	.....	.....	.....
325L	91	188	85	86	147	144	139	121	113	364	450	597	741
257..	120	141	102	(29)	.....	.....	131	121	...	363	(392)	.....	.....

TABLE NO. 14.—(Continued)

Hen No.	'08	'09	'10	'11	'12	'13	Averages 2 Yr.	3 Yr.	4 Yr.	Total Production 3 Yr.	4 Yr.	5 Yr.	6 Yr.
163..	119	155	87	108	.....	.....	137	120	117	361	469	.....	.....
353..	76	153	128	84	92	116	115	119	110	357	441	533	649
205U	163	152	41	41	35	98	158	119	99	353	397	432	530
278L	80	151	120	87	144	131	116	117	110	351	438	582	713
206..	84	131	36	(12)	.....	.....	*138	117	...	351	(363)	.....	.....
340..	75	159	103	.....	.....	.....	*117	112	...	337	.....	.....	.....
362..	92	125	106	.....	.....	.....	*109	108	...	323	.....	.....	.....
291..	74	126	111	.....	.....	.....	*100	104	...	311	.....	.....	.....
357..	108	119	82	(10)	.....	.....	*114	103	...	309	(319)	.....	.....
252..	83	126	98	45	30	.....	105	102	88	307	352	382	.....
268..	107	111	82	.....	.....	.....	*109	100	...	300	.....	.....	.....
347..	120	104	69	(27)	.....	.....	112	98	...	293	(320)	.....	.....
354..	58	133	100	(64)	.....	.....	96	97	...	291	(355)	.....	.....
312..	86	116	80	41	79	.....	101	94	81	282	323	402	.....
112..	32	104	139	.....	.....	.....	* 68	92	...	275	.....	.....	.....
240..	76	94	88	46	(22)	.....	85	86	76	258	304	(326)	.....
363L	91	116	42	24	47	13	103	83	68	249	273	320	333
281..	98	69	82	.....	.....	.....	*134	83	...	249	.....	.....	.....
230..	89	104	100	.....	.....	.....	*147	78	...	293	.....	.....	.....
110..	83	121	17	(17)	.....	.....	*102	74	...	221	(238)	.....	.....
	147	177	147	78	108	103	162	157	139	—1st ten.			
	134	156	134	94	84	74	145	141	129	—2nd ten.			
	121	149	129	78	87	92	136	133	119	—3d ten.			
	104	146	122	83	118	123	125	123	113	—4th eight.			
	105	140	91	73	75	115	123	112	105	—5th ten.			
	84	107	80	37	63	13	106	88	75	—6th ten.			
	117	146	117	78	87	93	133	126	117	—flock average.			
	(58)	(58)	(58)	(31)	(24)	(14)	(58)	(58)	(31)	—No. of hens.			
	141	167	141	89	87	82	154	149	133	—highest twenty.			
	95	123	86	60	71	89	114	100	94	—lowest twenty.			

TABLE NO. 15—PRODUCTION BY YEARS OF ALL HENS IN FLOCK OF 1908 THAT FINISHED THREE OR MORE YEARS' RECORDS.

Hen No.	'09	'10	'11	'12	'13	Averages 2 Yr.	3 Yr.	4 Yr.	Total Production 3 Yr.	4 Yr.	5 Yr.	
713.....	204	188	138	87	7	196	177	154	530	617	624	.....
550.....	200	160	132	(6)	.....	180	164	...	492	(498)	.....	.....
544.....	219	146	112	126	(8)	182	159	151	477	603	(611)	.....
720.....	193	140	132	(97)	.....	167	155	...	465	(562)	.....	.....
743.....	197	137	125	113	103	167	153	143	459	572	675	.....
594.....	167	146	143	(93)	.....	156	152	...	456	(549)	.....	.....
555.....	158	165	131	130	110	162	151	146	454	584	694	.....
734.....	216	140	92	134	125	178	149	146	448	582	707	.....
775.....	160	158	130	122	98	159	149	143	448	570	668	.....
593.....	197	114	126	102	62	156	146	135	437	539	601	.....
766.....	199	135	98	106	125	167	144	135	432	538	663	.....
565.....	155	156	108	119	.....	156	140	135	419	538	.....	.....
562.....	150	172	98	117	137	161	140	134	420	537	674	.....
841.....	169	126	117	101	115	148	137	128	412	513	628	.....
729.....	176	144	86	108	130	160	135	129	406	514	644	.....
551.....	206	101	94	105	90	153	134	127	401	506	596	.....
761.....	168	134	97	.....	.....	151	133	...	399	.....	.....	.....
752.....	171	106	116	.....	.....	139	131	...	393	.....	.....	.....
714.....	183	135	68	126	97	159	129	128	386	512	609	.....
586.....	164	130	92	124	64	147	129	128	386	510	574	.....
740.....	140	136	107	(9)	.....	138	128	...	383	(392)	.....	.....
755L.....	169	122	85	110	88	146	125	122	376	486	574	.....
587L.....	158	112	100	28	91	135	123	99	370	398	489	.....
773.....	152	122	87	57	.....	137	120	105	361	418	.....	.....
739.....	139	135	87	.....	.....	137	120	...	361	.....	.....	.....
745.....	138	159	47	39	2	148	115	96	344	383	385	.....
540.....	143	143	55	.....	.....	143	114	...	341	.....	.....	.....
592L.....	188	109	42	166	(62)	149	113	126	339	505	(567)	.....
595.....	171	99	67	97	.....	135	112	109	...	434	.....	.....
767.....	138	116	73	.....	.....	127	109	...	327	.....	.....	.....
711L.....	109	103	102	119	119	106	105	108	314	433	552	.....
458L.....	99	120	97	86	(47)	110	105	101	316	402	(449)	.....
526.....	134	99	78	66	(16)	116	104	94	311	377	(393)	.....
769.....	132	111	70	.....	.....	121	104	...	313	.....	.....	....
501.....	149	85	77	.....	.....	117	104	...	311	.....	.....	.....
566L.....	114	114	81	63	115	114	103	93	309	372	487	.....
584.....	154	122	30	.....	.....	138	102	...	306	.....	.....	.....
147U.....	114	114	74	133	103	114	101	109	302	435	538	.....
570.....	133	91	77	50	.....	112	100	88	301	351	.....	.....

TABLE NO. 15—(Continued)

Hen No.	'09	'10	'11	'12	'13	Averages 2 Yr.	3 Yr.	4 Yr.	Total Production 3 Yr.	4 Yr.	5 Yr.	
575L.....	126	94	69	96	.....	110	93	94	280	376	.....	.....
735U.....	137	111	28	(...)	86	124	92	91	276	362	(...)	.....
569.....	170	60	39	.....	.....	115	90	...	269	.....	.....	.....
518.....	95	104	53	.....	.....	100	84	...	252	.....	.....	.....
596.....	106	72	47	(9)	.....	89	76	...	225	(234)	.....	.....
718.....	104	83	15	19	.....	94	67	55	202	221	.....	.....
751.....	101	52	41	39	.....	77	65	58	194	233	.....	.....
747L.....	112	43	24	36	117	78	60	54	179	215	332	.....
599L.....	84	45	31	31	40	65	53	48	160	191	231	.....
792L.....	118	23	18	13	30	72	53	43	159	172	202	.....
	191	149	126	116	84	170	156	145	—1st ten.			
	174	134	97	113	108	154	135	131	—2d ten.			
	155	126	75	83	60	141	119	110	—3d nine.			
	128	107	76	86	112	117	104	99	—4th ten.			
	115	69	36	39	68	92	73	63	—5th ten.			
	153	117	82	90	89	135	117	110	—flock average.			
	(49)	(49)	(49)	(34)	(23)	(49)	(49)	(34)	—No. of hens.			
	183	142	112	115	97	162	145	137	—highest twenty.			
	121	88	56	63	87	105	88	80	—lowest twenty.			

TABLE NO.16—PRODUCTION BY YEARS OF ALL HENS IN FLOCK OF 1909 THAT FINISHED THREE OR MORE YEARS' RECORDS.

Hen No.	'10	'11	'12	'13	Averages 2 Yr.	3 Yr.	4 Yr.	Total Production 3 Yr.	4 Yr.		
96U	195	193	138	161	194	175	172	526	687	.....	....
866L	199	181	146	(72)	190	175	...	526	(598)	.....	.....
880L	176	184	164	(40)	180	175	...	524	(564)	.....	.....
914L	206	178	136	(30)	192	173	...	520	(550)	.....	.....
906L	221	162	132	74	192	172	147	515	589	.....	.....
106U	203	149	149	152	176	167	163	501	563	.....	.....
125V	158	175	150	130	167	161	153	483	613	.....	.....
103V	187	144	138	.....	166	156	...	469	.....	.....	.....
890L	181	139	146	159	160	155	156	466	625	.....	.....
846L	194	132	127	(2)	163	151	...	453	(455)	.....	.....
870	180	129	138	146	154	149	148	447	593	.....	.....
100V	156	147	141	.....	152	148	...	444	.....	.....	.....
149U	191	104	147	146	148	147	147	442	588	.....	.....
470	193	120	126	148	157	146	147	439	587	.....	.....
913L	188	125	121	.....	157	145	...	434	.....	.....	.....
869L	154	136	143	101	145	144	134	433	534	.....	.....
142U	189	104	129	132	147	141	139	422	554	.....	.....
482L	188	103	(...)	125	145	139	(...)	416	(...)	.....	.....
892L	190	96	122	77	143	136	121	408	485	.....	.....
120U	160	138	108	43	149	135	112	406	449	.....	.....
476L	204	88	100	119	146	131	128	392	511	.....	.....
919L	129	133	124	106	131	129	123	386	492	.....	.....
920L	156	97	134	88	127	129	119	387	475	.....	.....
848L	177	84	126	56	131	129	111	387	443	.....	.....
905L	156	121	108	(58)	139	128	...	385	(443)	.....	.....
110U	164	100	116	106	132	127	122	380	486	.....	.....
974	147	137	96	94	142	127	119	380	474	.....	.....
112U	163	89	126	(23)	126	126	...	378	(401)	.....	.....
853L	127	109	139	93	118	125	117	375	468	.....	.....
896L	167	106	102	86	137	125	115	375	461	.....	.....
163U	172	85	103	95	129	120	114	360	455	.....	.....
26U	137	115	105	57	126	119	104	357	414	.....	.....
157U	136	95	125	(66)	116	119	...	356	(422)	.....	.....
918L	142	115	86	.....	129	114	...	343	.....	.....	.....
876L	123	89	123	120	106	112	114	335	455	.....	.....
105U	174	95	63	71	135	111	101	332	403	.....	.....
146U	128	128	67	(31)	128	108	...	323	(354)	.....	....
139U	128	83	111	89	106	107	103	322	411	.....	.....

TABLE NO. 16—(Continued)

Hen No.	'10	'11	'12	'13	Averages 2 Yr.	3 Yr.	4 Yr.	Total Production 3 Yr.	4 Yr.	
173U.....	130	69	80	(57)	100	93	...	279	(336)	....
172U.....	132	90	56	(27)	111	93	...	278	(305)	....
144U.....	80	77	102	116	79	86	94	259	375	....
126U.....	74	85	98	109	80	86	92	257	366	....
109U.....	97	79	79	83	88	85	85	255	338	....
895L.....	112	47	87	(22)	80	82	...	246	(268)	....
111U.....	157	56	15	(2)	107	76	...	228	(230)	....
129U.....	96	68	60	(45)	82	75	...	224	(269)	....
115U.....	89	38	90	65	64	72	71	217	282	....
133U.....	87	32	68	61	60	62	62	187	248	....
	192	164	143	135	178	166	158	498	633—1st ten.	
	179	120	131	115	150	143	135	429	543—2d ten.	
	162	106	116	95	134	128	120	384	480—3d eight.	
	143	102	102	87	123	116	110	348	438—4th ten.	
	105	64	74	87	85	81	81	243	322—5th ten.	
	156	111	113	103	134	126	121	380	...—flock averg.	
	(48)	(48)	(47)	(31)	(48)	(48)	(30)	(48)	...—No. of hens.	
	185	142	130	123	163	154	152	...	...—highest 20.	
	124	83	88	87	103	98	98	...	...—lowest 20.	

TABLE NO. 17—PRODUCTION BY YEARS OF ALL HENS IN FLOCK OF 1910 THAT FINISHED THREE OR MORE YEARS' RECORDS.

Hen No.	'11	'12	'13	Averages 2 Yr.	3 Yr.		Total Production 3 Yr.			
7	143	221	202	182	189	...	566	...	...	...
64	120	186	179	153	162	...	485	...	...	...
9	92	192	195	142	160	...	479	...	...	...
43	100	209	150	155	153	...	459	...	...	...
91	140	171	144	156	152	...	455	...	...	...
87	138	166	137	152	147	...	441	...	...	...
95	117	154	164	136	145	...	435	...	...	...
97	162	151	120	157	144	...	433	...	...	...
78	92	182	151	137	142	...	425	...	...	...
16	89	184	151	137	141	...	424	...	...	...
94	120	169	125	145	138	...	414	...	...	...
60	50	204	157	127	137	...	411	...	...	...
80	91	180	133	136	135	...	404	...	...	...
59	78	177	146	128	134	...	401	...	...	...
45	88	150	162	119	133	...	400	...	...	...
44	105	174	120	140	133	...	399	...	...	...
5	102	131	161	117	131	...	394	...	...	...
101	112	157	114	135	128	...	383	...	...	..
53	87	158	136	123	127	...	381	...	...	...
38	62	144	170	103	125	...	376	...	...	...
89	100	130	143	115	124	...	373	...	...	...
69	121	139	109	130	123	...	369	...	...	...
4	104	140	125	122	123	...	369	...	...	...
8	71	118	169	95	119	...	358	...	...	...
88	102	97	157	100	119	...	356	...	...	...
67	85	119	150	102	118	...	354	...	...	...
57	67	147	140	107	118	...	354	...	...	...
2	78	161	99	120	113	...	338	...	...	...
79	76	142	107	109	108	...	325	...	...	...
125	53	150	110	102	104	...	313	...	...	...
10	94	132	87	113	104	...	313	...	...	...
123	69	167	69	118	102	...	305	...	...	...
14	98	51	151	75	100	...	300	...	...	...
131	37	121	126	79	95	...	284	...	...	...
1	80	114	85	97	93	...	279	...	...	...
56	61	117	97	89	92	...	275	...	...	...
58	90	65	103	78	86	...	258	...	...	...
	119	182	159	151	154	...	460—1st ten.			
	90	164	142	127	132	...	396—2nd ten.			
	93	127	142	110	121	...	362—3rd seven.			
	74	122	103	98	100	...	299—4th ten.			
	94	151	136	122	127	...	381—flock average.			
	(37)	(37)	(37)	(37)	(37)	...	(37)—No. of hens.			
	105	173	151	139	143	...	...—highest 20.			
	82	124	119	103	108	...	...—lowest 20.			

TABLE NO. 18—PRODUCTION BY YEARS OF ALL HENS IN FIRST FOUR FLOCKS THAT FINISHED ONLY TWO YEARS' RECORDS.

Flock of 1907			Flock of 1908			Flock of 1909			Flock of 1910		
Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr.
342	89	98	522L	136	133	912L	187	122	*83	127	144
232	121	144	527	116	105	901L	135	15	25	115	170
398	85	113	539	122	5	893	154	110	42	131	175
253	69	135	563	177	98	878L	135	68	12	90	187
248	131	127	574	42	51	170U	168	79	36	78	152
258	102	155	583	120	91	159U	139	86	37	88	112
259	129	101	589	142	109	132U	155	108	30	96	165
262	105	79	591	151	46	128U	154	85	35	98	164
284	123	113	706	195	127	489L	144	73	124	49	128
313	75	159	716	116	118	907L	168	121	132	39	98
350	94	106	719	146	129	877L	186	37	122	55	74
364	129	54	722	156	143	867L	139	131	121	69	110
368	93	86	730	143	91	864L	131	53	120	96	149
165	93	164	762	153	102	860L	141	85	118	40	51
201	136	140	768	120	145	858L	137	46	114	56	111
209	133	108	770	142	109	857L	114	84	113	44	169
212	96	60	776	142	74	844	160	38	111	56	115
217	145	149	777	140	141	198U	122	93	110	27	145
222	137	128	781	146	79	169U	146	208	109	59	161
234	79	118	783	126	93	168	109	79	108	81	131
238	69	98	793L	82	50	164U	135	76	107	103	133
239	89	187	839L	150	106	158U	119	80	104	101	191
334	140	150	568	158	201	155U	127	23	102	110	170
335	93	81	780	144	111	153U	96	31	72	128	119
344	105	156	507	68	41	150U	83	70	93	130	131
337	119	134	510	78	42				86	105	199
424	82	94	511	114	109				84	84	103
333	117	109	516	151	69				81	90	109
331	160	145	517	79	118				76	79	33
314	122	142	520	46	45				68	79	97
228	72	26	530	115	96				63	97	131
225	81	74	545	73	118				54	58	84
207	124	77	559	129	139				50	47	148
			564L	102	152				40	17	118
			567	90	19				34	98	166
			597	114	81				33	81	137
			703L	123	27				26	154	193
			715	128	106				24	106	128
			726L	156	122				22	91	152
			738	143	111				20	74	149
			742	150	112				19	69	72

TABLE NO.18—(Continued)

Flock of 1907			Flock of 1908			Flock of 1909			Flock of 1910		
Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr.	Hen No.	1st Yr.	2nd Yr
			744	110	38				18	74	144
			746	80	75				15	78	134
			753	122	38				11	87	151
			759	123	85				90	89	139
			772	138	24				96	122	68
			790	108	126				126	55	130
			840L	134	87				71	96	192
			502	127	125				98	93	164
									65	121	89
									145	75	184
									99	99	136
									812R	102	63
									650R	55	132
									647R	111	118
									81	64	45
									82	118	134
									52	50	88
									135R	80	145
									29	93	117
									6	74	153
									100	118	68
									75	100	80

TABLE NO. 19—PRODUCTION OF ALL HENS IN FIRST FOUR FLOCKS THAT FINISHED ONLY ONE YEAR'S RECORD.

Flock of 1907			Flock of 1908			Flock of 1909			Flock of 1910		
Hen No.	1st Yr.		Hen No.	1st Yr.		Hen No.	1st Yr.		Hen No.	1st Yr.	
246	96	...	531	120	...	99U	122	...	646R	64	...
318	87	...	538	143	...	474	209	...	130R	78	...
329	135	...	542	152	...	469	194	...	61	126	...
346	199	...	556	157	...	483L	150	...	129	41	...
348	86	...	560	147	...	482L	199	...	127	35	...
349	135	...	572	53	...	469L	201	...	85	101	...
382	112	...	702	219	...	898L	179	...	77	87	...
315	177	...	707	140	...	886L	174	...	17	65	...
164	100	...	723	130	...	875	205	...	66	130	...
157	128	...	732	138	...	849	134	...	666R	67	...
203	103	...	737	151	...	473L	199	...	51	42	...
208	85	...	748	152	...	165U	118	...	49	45	...
215	133	...	750	99	...	145U	62	...	48	96	...
219	65	...	754	130	...	137U	201	...	47	60	...
223	119	...	764	92	...	113U	138	...	39	40	...
233	53	...	765	106	...	108	120	...	31	74	...
237	127	...	503	116	...	107U	145	...	27	63	...
249	54	...	505	112	...	104U	150	...	85	91	...
260	53	...	513	165	...	102U	162	...	119R	106	...
272	57	...	528	160	...	101U	196	...	92	92	...
282	61	...	529	163	...	471L	272	...	74	55	...
338	72	...	535	93	...	166U	141	...	...	...	...
339	62	...	536	97	...	486L	231	...	...	...	...
369	55	...	548	136	...	...	...	...	...	...	...
328	56	...	561	113	...	...	...	...	...	...	...
384	30	...	577	100	...	...	...	...	...	...	...
401	60	...	580	139	...	...	...	...	...	...	...
376	57	...	585	154	...	...	...	...	...	...	...
388	62	...	590	139	...	...	...	...	...	...	...
397	39	...	731	95	...	...	...	...	...	...	...
...	...	...	728	105	...	...	...	...	...	...	...
...	...	...	741	170	...	...	...	...	...	...	...
...	...	...	763	138	...	...	...	...	...	...	...
...	...	...	774	53	...	...	...	...	...	...	...
...	...	...	786	115	...	...	...	...	...	...	...
...	...	...	788	146	...	...	...	...	...	...	...
...	...	...	791	116	...	...	...	...	...	...	...

Value of Selecting on the Three Year Averages.

The remarkable uniformity of the three year averages as shown by Tables Nos. 3 and 6, together with the fact that flock averages after that time appear to be nearly uniform, indicates that the three year average is a safe basis for judging of the productivity of an individual.

Eliminating all hens no matter how high their previous records that did not finish the third year and all of those that were alive then but whose total production to that time had been low should give a severe selection for vigor of flock.

The remainder of the flock should possess both vigor and profitable production. If only progeny from the more productive strains within these limits were retained the results should in time furnish a very good basis for the determination of the value of selection in this strain of poultry. This subject will, however, be taken up in detail in a later publication.

E. SUMMARY AND CONCLUSIONS.

1. The six flocks of hens under consideration in the experiment range in age from seven years down to one year.

2. They are all descended from a small number of individuals introduced into the poultry plant some nine or ten years ago.

3. Taken as a whole, these flocks are practically unselected as far as egg production is concerned. They have, however, always been severely selected for vigor and in a few cases some of the lower producers have been discarded, but in every case some have been retained.

4. As far as it has been possible to ascertain, this is the first experiment to be reported in which a series of yearly flocks has been kept through a long period of time (throughout life).

5. The number of variable factors that may affect the egg production of a flock of hens is so great that it will require a long series of years of experimentation before the probable effect of a given factor can be definitely stated.

6. One of the most serious drawbacks to successful egg production has been the supposed necessity of constantly renewing the flock. If a strain of fowls can be developed in which the majority of the flock will continue to produce profit-

ably for from three to five years and many of them for double that period it will materially reduce this burden.

7. Some of the conclusions reached in studying the results of this experiment are startling and somewhat revolutionary in character. They are, however, so consistently supported by the records of the different flocks that it has been thought best to publish them at this time.

8. The average productive life of this strain of fowls appears at the present time to be about four years.

9. The average first year production of all flocks was 124 eggs. The average second year production was exactly the same as the first, while the average of the third year was only one dozen less.

10. The normal variation in first year flock averages of this strain of fowls is apparently between 100 and 160 eggs, the second year between 105 and 140, and the third year between 100 and 130. After that the average for all ages has been very close to 90 eggs per year.

11. There appears to be a fairly definite potential laying capacity for a flock of this strain of fowls which finds expression in the first three years.

12. The total production of a flock for the first three years appears to be the same regardless of whether the first year record was extremely high, extremely low, or medium in amount.

13. Nearly all of the longer-lived hens of a flock will lay over 500 eggs; the majority of them will lay over 600 or 700, while individual records running from 800 up to nearly 1,000 eggs may be expected.

14. Considering only hens that have made three or more years' records and the uniformity of the three year averages is still more striking.

15. An average production for the flock of 127 eggs per year for three years is unquestionably profitable and indicates good constitutional vigor.

16. The factors that have affected the flock averages from year to year have affected all the individuals in those flocks alike.

17. The difference between the highest and lowest records in a flock has averaged 170 for the first year and 182 for the second year.

18. In the flocks making low first year records the second

and third year records were high and there was little difference in production in these two years between the high layers and the low layers of the first year.

19. In the flocks making high first year records the second and third years' records were low but the higher layers of the first year continued to be the highest producers.

20. The ten hens making the highest second year's record gave a higher three year total than the ten making the highest first year record.

21. More hens have made their highest year's record after the first year than during that year. Three hens made their highest record the fifth year.

22. The value of selection for egg production in poultry cannot be judged from a short series of first year flock averages all falling within the normal range of variation.

23. Selecting the high layers from a flock with a high first year record would have improved the flock; selecting in the same way from a flock with a low first year record would have been of little value.

24. Nearly all the hens in these flocks whose total production has been extremely high have made low or only medium first year records.

25. From these studies it appears that the three year average is the most reliable index of the value of a given individual